Scaling of dive duration among water birds with contrasted swimming modes

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Diving birds use either foot stroking or wing flapping for swimming. Different swimming modes affect the energetic cost of the animals and are expected to affect dive duration. We hypothesized that (1) the wing-propelled birds dive longer than foot-propelled birds because the energetic cost in the wing-propelled birds is lower than that of foot-propelled birds, and (2) the slope of the regression line of dive duration versus body mass is steeper in wing-propelled birds than in foot-propelled birds because the difference in the energetic cost between the two swimming modes increases with body mass. Here, we examined the scaling relationship of maximum dive duration in wing-propelled birds (25 species; mass range, 0.14–24.6 kg) and foot-propelled birds (36 species; mass range, 0.15–4.98 kg) with phylogenetically informed statistical methods. We also calculated the theoretical aerobic dive limit (tADL), representing the dive duration predicted from oxygen store and oxygen consumption rate, and compared it with the mean dive duration in 52 diving bird species. Wing-propelled birds dived longer than foot-propelled birds for a given body mass, with the regression line of the wing-propelled birds (slope: 0.51) being gentler than that of foot-propelled birds (slope: 0.73). Our result provides support for the hypothesis (1) but not hypothesis (2). The steep regression slope in the foot-propelled birds seems to be caused by the maximum dive duration of larger foot-propelled birds, exceeding that of wing-propelled birds. Furthermore, our results indicate that the dive durations of foot-propelled birds are closer to tADL than those of wing-propelled birds. This finding might reflect that most of the foot-propelled birds are benthic foragers: the dive duration of many benthic foragers reaches or exceeds their tADL to maximize foraging time near the bottom. In conclusion, our study indicates that swimming mode constrains dive duration in diving birds.